# A. 2.20 MARS EXPLORATION PROGRAM ADVANCED TECHNOLOGIES

## 1.0 Scope of Program

NASA's Mars Exploration Program (MEP) calls for a series of highly ambitious missions through the end of the decade and beyond. The overall goals of the MEP must be achieved with relatively low mission risk and within tightly constrained cost resources. Information on NASA's Mars Exploration Programs may be obtained from the World-Wide Web at URL http://mars.jpl.nasa.gov/overview/index.html

The Mars Technology Program (MTP) research solicited in this NRA will support the technology development needs of missions to be launched during or after the 2009 launch opportunity.

Technology developments proposed in response to this solicitation must be justified by a brief but complete discussion of the value added by the technology to a potential Mars science investigation. Proposals must outline plans for making technologies developed under this NRA available to NASA missions regardless of the technology developer's participation in the mission (including Scout missions selected through later competitions).

Future MEP missions are outlined in the following paragraphs for a quick review.

*Mars Science Laboratory (MSL) 2009*

The MSL mission is intended to push the state-of-the-art of *in situ* scientific observations of Mars, demonstrate several technologies critical to a possible follow-on Mars Sample Return (MSR) mission, and provide information vital for implementing the entire MEP. The MSL mission will take advantage of a rich legacy of remote sensing observations by targeting a preselected site of high scientific interest. Advanced instruments will form an analytic laboratory on the surface. MSL will also demonstrate precision landing technologies, it may carry a rover capable of traversing greater than five kilometers across the Martian surface, and it may access the planet's subsurface for the first time. The *Mars Science Laboratory* (MSL) mission is currently scheduled for launch in 2009.

*Future Potential Missions 2010-2020*

A variety of missions are possible in the period 2011-2020, including landers, rovers, orbiters, and a Mars sample return mission. The decision on which missions are selected, and how they should be sequenced, depends on discoveries to be made in the next several years.

In addition to these specified missions, a second round of Mars Scouts may be implemented. The first of NASA's Mars Scout missions are planned for launch in 2007. The Mars Scout program is designed to open up exciting new vistas on Mars by implementing innovative science investigations that will augment the core MEP missions planned by NASA in cooperation with the science community. Within the Mars Scout program, investigation platforms may include airborne vehicles, landers, rovers, and subsurface explorers. Although there is not enough lead-time to influence technology development for a 2007 Scout mission, there is significant interest in additional Scout missions in the next decade.

To take advantage of this wide range of mission opportunities, NASA requires the development of innovative technologies. Because of limited spacecraft accommodations, scientific instrumentation and supporting infrastructure elements must be robust and have low power, volume, mass, telemetry bandwidth, and operational overhead requirements. Spacecraft instruments need to operate autonomously or allow supervised teleoperation while conducting complex *in situ* sample analyses. Successful technologies will have to operate in environments characterized by extremes of temperatures, pressures, gravity, high-g landing impacts, vibration, and thermal cycling.

In addition to operating in extreme environments, these technologies may be deployed to multiple locations within the investigation site, thereby requiring the integration of suites of instruments with mobility and manipulation systems that are capable of locating, and then traveling to, sites of interest, placing the instruments in contact with precisely identified targets, and/or acquiring samples and placing them in contact with the instrument sensors, conducting *in situ* analysis, and communicating the analysis results to Earth. It is anticipated that such mobility systems will also be required to include infrastructure elements for supported science instruments (e.g., communications, computation, structural support, thermal control, power, etc.).

Such ambitious mission plans require that many new technologies be brought to a Technology Readiness Level (TRL) of 6 (see http://www.hq.nasa.gov/office/codeq/trl/trl.pdf for TRL definitions) so that they can be developed to a flight ready status within a short time span and at minimum cost. Therefore, this NRA solicits proposals for research and development to advance the readiness of high priority technologies. Some areas specify low to mid TRL technology development for missions that may be launched in the 2010-2020 decade. In particular, the following technology areas have been identified as of highest priority for this solicitation (numbers refer to the reference section below, and do not reflect a priority order):

- 2.1 Subsurface Access,
- 2.2 Rover Technology,
- 2.3 Telecommunications and Navigation,
- 2.4 Planetary Protection,
- 2.5 Advanced Entry, Descent, and Landing (EDL), and
- 2.6 Technologies for Low Cost Missions.

Further information for each technology area is provided below.

## 2.0 Specific Topic Areas

### 2.1 Subsurface Access

One of the essential elements of the future exploration of Mars will be the ability to explore the Martian subsurface. There are many technologies of relevance to this objective, including orbital geophysical investigations (including ground penetrating radar), ground-based geophysics (including both stationary and mobile methods), methods of physically accessing the subsurface (i.e., drilling, scooping, penetrating, etc.), and analytic technologies for collecting data either from instruments inserted into the subsurface or from samples recovered to the surface. Any number of these may be integrated to produce an overall subsurface exploration strategy. Because of the importance of subsurface access in testing geophysical, geochemical, and biological models, along with the large uncertainty in what is technically possible by robotic means, this NRA is directed to making advances in subsurface access technologies as outlined below:

- Complete, lightweight subsurface access systems for regolith only, with a penetration depth of 0.5 m. The system should be retractable so that it can be used for multiple penetrations from a mobile platform. TRL 6 is required by August 2005. The development should focus on significant reduction in mass from the currently available state-of-the-art interplanetary drilling systems. The system should include provision for automated collection of multiple samples of scientific interest, and automation with all the necessary sensors for real-time control loops. The capability of delivering downhole instruments of relevance to Mars science is especially desirable.

- Complete, lightweight drill systems with a penetration depth of at least 1 m, with the capability of penetrating both regolith and rocks. TRL 6 is required by August 2005. The development should focus on significant reduction in mass from the currently available state-of-the-art interplanetary drilling system. The drill system should include provision for hole stability, automated, multiple sample collection and automation with all the necessary sensors for real-time control loops, e.g., control for rate of progress, weight-on-bit, avoidance of jamming, etc. However, the automation need not include high level decision making capability. The capability of delivering downhole instruments of relevance to Mars science is especially desirable.

- Complete drill systems for drill depths of 10-20 m (high priority). For future missions, it is not known at this time whether the limiting resource will be mass, power, volume, or time—nonetheless, it is certain that all of these will need to be minimized. Given present mission concepts, basic drill systems with a mass at or below 25 kg (additional mass allowed for hardware extensions required for the depth) are of high interest. The drill system should include provisions for hole stability, automated collection of multiple samples, and automatic mechanization. The drill must be able to penetrate both regolith and a variety of probable Martian rock types. TRL 5 is required by August 2005. For TRL 5, flight qualified materials are to be used for drill bits and rods (for thermal validation)—nonflight materials are sufficient for other components. Some mature technologies may be proposed if they will reach TRL 6 by September 2006. For such systems, the drill system must include automation with sensor feedback for real time control as described above.

In all cases the drill designs should include taking samples at various depths. If cores are generated, they should be delivered in segments no greater than 10 cm long and 1-1.5 cm diameter. If irregular rocks are collected, they should be < 5 cm diameter.

Note that TRL 5 requires a controlled field test as well as a demonstration of the stress on drill bit (flight materials) at low temperature (-30° to -40°C) either by drilling a hole through material held at this temperature, or by some other sort of low temperature lab test, to establish that the bit does not become brittle at this temperature. TRL 6 requires calibration and performance evaluation as an integrated prototype (engineering model) in a simulated Martian environment (temperature, pressure and composition).

The indicated mass target represents current best estimates at TRL 6 without contingency. Contingency mass reserves will be kept at the overall payload system level.

## 2.2 Rover Technology

Proposals are requested in several areas outlined below that will develop capabilities that may be needed by the Mars Science Laboratory (MSL) Project, as well as future Mars missions with rover payloads. If targeted for the MSL mission, performance objectives should be consistent with a long range, single rover, science exploration mission to Mars as currently envisioned for the 2009 opportunity. Researchers should anticipate integration of the developed technologies with the Coupled Layer Architecture for Robotic Autonomy (CLARAty – see http://robotics.jpl.nasa.gov/tasks/claraty/homepage.html for details) now being developed by the MEP and demonstration of the developed technologies in a systems-level testbed environment by mid-2005. Where appropriate, documentation of theoretical and experimental validation of CLARAty-compatibility is encouraged.

### Long-Range Autonomous Navigation

- Demonstrate capabilities for long distance (greater than 5 km) traverses through natural terrain, utilizing no *a priori* knowledge of the subject terrain other than overhead "descent images" of >1 m/pixel resolution, and global localization coordinates. The selected terrains will be similar to Viking Lander 1-class terrains, with representative topologies, rock distributions, and morphology. The entire traverse must be conducted with less than 30 command cycles (uplinks). Downlink data must include localization imagery, science payload data, rover engineering performance data, and sufficient visualization information to permit scene reconstruction and modeling.

### Very Rough Terrain Navigation

- *Trajectory Generation:* Including continuous motion precision trajectory control; motion execution with a set of canonical discontinuous motion primitives (e.g., parallel parking, crabbing, six wheel steering, tank steering, limited steering angle motion execution, etc.); and explicit consideration of the mobility characteristics of six-wheeled rocker-bogey mobility systems.

- *Navigation:* Dense terrain path determination including full configuration space search techniques; full consideration of vehicle and terrain characteristics that are typically not isotropic; high performance, nonvisual, reactive sensing and control strategies; and explicit consideration of limited sensing, computation, power, and mobility of flight systems (vs. terrestrial testbed/development systems).

- *Improved Hazard Detection:* Including robust step and hole detection from all view angles; improved terrain characterization; detection and avoidance of unstable terrain, wheel traps, and soft soil sink hazards; and alternate sensing strategies (e.g., proximity and contact sensing).

- *Improved Position and Attitude Estimation:* Environmental expectation correlation (e.g., visual and contact measurement of terrain contour); and reliable tracking of precision trajectories specified for traversing rough terrain with tight tolerances.

Environment State Estimation

- *Improved Sensor Processing:* Terrain contact information (e.g., from suspension articulation monitoring); alternate sensing techniques (e.g., radar, laser ranging); multispectral and spatial analysis (e.g., color and texture); noncontact soil cohesion and friction estimation; and other sensor-based inferencing to estimate environmental conditions.

- *Symbolic Representation:* Including combination of multiple sensing modes to qualify environmental components; extraction of geometric bounds of terrain features with accurate and reliable description assignment; multiple, context dependent representations of the environment (e.g., science or navigation); and correlation of simulated and real environments.

Instrument Placement

- *Target Tracking:* Techniques for reliable autonomous rendezvous with natural terrain features designated from a distance and navigation and obstacle avoidance while doing same; correlation of multiple views of the same target from varying distances and cameras (e.g., narrow and wide field of view optics); correlation of target images from different view angles and lighting conditions; and reliable transfer of control from mobility system to manipulation system for single day approach and instrument placement.

- *Manipulator Design:* Improved tools for design, and design results for manipulation systems, to perform contact and noncontact operations of a long duration rover facility, including operations such as drilling, grasping, contact science instrument placement (fine and coarse positioning), sample acquisition, sample transfer, and noncontact instrument alignment (e.g., for spectrometers and imagers), and the interaction of these systems with each other and subsystems to be specified for onboard sample processing, including simulation and operations interface capabilities conforming to the mission-selected software environments.

- *Manipulation Planning:* Full rover/manipulator approach planning including system and environment constraints and uncertainties; sensor planning for all contact and noncontact instruments and their coordination; arm trajectory planning; and sequence generation.

- *Manipulator Control:* Contact and force control from a mobile compliant platform; collision avoidance and detection; hand-eye coordination; and manipulator and sensor system calibration.

- *State Estimation:* Multisensor estimation of manipulator state (including position, contact, force, and health) within flight manipulator design constraints.

- *Error Handling:* Detection of error conditions during operation; conditional operations to diagnose situation (e.g., capture imagery from useful view angle); autonomous recovery from off-nominal manipulation system performance; and alternate planning, control, and estimation, techniques for use of degraded manipulation system capabilities (e.g., loss of actuator).

2. 3 Telecommunications and Navigation

Technology initiatives are solicited that will significantly increase the data return from future Mars missions. While improved direct-to-Earth communications will continue to play an important role for orbiters and large landers, relay communications through infrastructure orbiters (science orbiters with relay payloads, as well as potential future dedicated telecom orbiters) will play an increasingly important role in terms of significantly augmenting data return for *in situ* spacecraft and enabling new mission concepts (e.g., aerobots, microprobes, small Scout-class landers) for which direct-to-Earth communications are not feasible. In addition, concepts are solicited for obtaining Mars-relative position information based on radiometric observables extracted from these *in situ* telecommunications links.

The MEP Focused Technology Project is currently investing in the development of the "Electra" proximity link telecommunication and navigation payload that will fly on the 2005 Mars Reconnaissance Orbiter and all subsequent Mars orbiters to provide forward and return link UHF relay communications services, as well as navigation and timing services, to future Mars missions. Key features of the Electra payload include extensive flight reprogramming capability, frequency agility, and compliance with the CCSDS Proximity-1 Link Protocol. This payload also supports the optional addition of an X-band (8.4 GHz) receive channel, to enable infrastructure orbiters to receive high rate telemetry from the X-band direct-to-Earth radio systems of future landers. Tasks selected in this NRA must be complementary to and compatible with this already planned focused technology investment (see further details at http://centauri.larc.nasa.gov/mars/High_Level_Electra_Descript_1.pdf).

Specific concepts are solicited in the following areas:

- Concepts and demonstrations of next-generation software transceiver architectures, featuring increased levels of reprogrammability and onboard processing capability, and incorporating fully integrated navigation with improved radio metric observable accuracies.
- Packaging and device integration prototyping efforts aimed at high capability proximity communications payloads for future Mars Science Laboratory (MSL)-class landers, with significantly reduced mass and power relative to current designs.
- Extremely low mass, low volume, low cost microtransceivers suitable for use on highly mass- and energy-constrained assets such as aerobots, microrovers, penetrators, and small network landers.
- Highly integrated general-purpose RF integrated circuit chip sets for Class S radio applications, including linear and QPSK (Quadrature Phase Shift Keying) phase modulators, image reject mixers, low noise amplifiers, etc.
- Improved UHF proximity link antennas, including directional (10-20 dBi) UHF antennas for future Mars telecommunications orbiters and low mass “omnidirectional” antennas for future landers.
- Highly directional, high frequency proximity link communications systems for extremely high rate (10-100 Mbps) surface to orbiter relays. Dual-use directional lander radio systems supporting low rate X-band direct-to-Earth links and high rate proximity links to relay orbiters.
- Improved analysis tools for modeling and simulation of lander and orbiter multipath effects on low gain proximity link antenna patterns.
- Next-generation proximity link protocol suite providing efficient and robust end-to-end data transport through multihop relay links.
- Algorithms and/or chipsets providing improved source and channel coding on Mars relay links.
- Precision *in situ* navigation techniques applicable to low mass, half-duplex communications systems.
- Novel techniques for robust capture of critical engineering telemetry during entry, descent, and landing (EDL)

## 2.4 Planetary Protection

This NRA is seeking proposals in the following area related to planetary protection:

Forward Contamination Avoidance.

> Technology development is solicited that will enable NASA to build, launch, and operate a mission that has subsystems with different Planetary Protection (PP) classifications, specifically for operating a Category IVb-equivalent subsystem from a Category IVa platform. See the following web site for NASA PP category definitions: http://nodis3.gsfc.nasa.gov/library/displayDir.cfm?Internal_ID=N_PG_8020_012B_&page_

name=main (note: the International Committee on Space Research (COSPAR) has recently proposed additional definitions for the levels of planetary protection; for the purposes of this NRA use the current NASA definitions).

Proposals for planetary protection technology should address at least the following two specific cases:

> Case 1: An instrument designed to investigate extant Martian life that is mounted on either a lander or a rover. In this case, the instrument must be maintained in a more sterile state (Category IVb-equivalent) than the rest of the platform (Category IVa-equivalent). In addition to the PP requirements on sterilization, science requirements may dictate that the instrument be assembled and maintained at a higher state of cleanliness than the rest of the landed system with respect to Earth contaminants. The instrument would need to be sterilized and cleaned at least once, and preferably more than once. If such a mission included a sample collection and delivery subsystem, that system would also have to comply with more stringent sterilization and cleaning restrictions.

> Case 2: A hardware subsystem that accesses a Martian environment needing special biologic protection but not for the purpose of delivering samples to life-related instruments. This subsystem could involve the collection of samples, or the emplacement of sensors. Such a subsystem would need to be sterilized to the standards of Category IVb. There would be no requirement to clean the spacecraft itself to a standard higher than Category IVa.

It is anticipated that the technology research proposed in response to this objective, will include (but will not necessarily be limited to) the following elements:

- Cleaning, sterilization, and validation technology,
- Biobarrier technology, and the management of barriers during various spacecraft operations, including during assembly, test, launch operations, launch, and operations on the Martian surface,
- Contaminant transport model,
- Experimental validation of the transport model, and
- Recommended implementation approach.

Sample Handling Systems.

Technology research is solicited that addresses barrier technologies that will provide the basis for a sample receiving laboratory capable of ensuring BSL-4 level containment of returned Martian samples, as well as class-100 or better protection of the samples themselves while allowing for samples to be analyzed and prepared for biohazard testing or precertification sterilization procedures. Systems are sought that will allow testing and preparation of the newly received samples (exclusive of biological testing) under human or robotic manipulation, as described in the following documents:

Space Studies Board, National Research Council, “Mars Sample Return: Issues and Recommendations,” Task Group on Issues in Sample Return. National Academy of Sciences, Washington, DC, 1997.

Space Studies Board, National Research Council. “Evaluating the Biological Potential in Samples Returned from Planetary Satellites and Small Solar System Bodies,” Task Group on Sample Return From Small Solar System Bodies. National Academy of Sciences, Washington, DC, 1998.

Rummel, J.D., M.S. Race, D.L. DeVincenzi, P.J. Schad, P.D. Stabekis, M. Viso, and S. E. Acevedo (eds.). “A Draft Test Protocol for Detecting Possible Biohazards in Martian Samples Returned to Earth,” NASA/CP-2002-211842, 2002.

Feasibility of the forward contamination approach must be demonstrated before August 2005 (MSL Preliminary Design Review), although it is anticipated that some work may continue after the feasibility demonstration. Feasibility for the sample handling approach should be demonstrable by early 2008.

## 2.5 Advanced Entry, Descent, and Landing (EDL)

Beyond MSL, Mars missions may need the capability to land much closer to a desired target and/or advanced methods of detecting, avoiding, or tolerating landing hazards. This solicitation supports the development of technologies needed for “pinpoint landing” (within tens of meters to 1 km of a target site), and advanced hazard detection/avoidance in the area of Advanced Entry, Descent, and Landing (EDL) as follows:

### Pinpoint Landing

- Methodologies suitable for use in both advanced hypersonic entry guidance and aerocapture guidance;
- Methodologies for autonomously compensating for wind drift on a parachute or other drag device during low altitude, low speed flight;
- Methodologies (including sensors) suitable for autonomous onboard identification of a preselected landing site from a stored onboard terrain map, and guidance and navigation to the site; and
- Methodologies for navigation with radiometric data involving the use of orbiting “beacon” spacecraft, and for filtering of radiometric and/or sensor-based tracking data for autonomous navigation during entry, descent, and landing.

### Hazard Detection/Avoidance

- Development of advanced active terrain mapping sensor providing increased range (>5 km), higher ranging accuracy (better than 5 m at 2 km and 0.04 meter at 80 m) higher field of regard (> 10x10 deg), high frame rate (>1 Hz), and

- Algorithms to interpret sensor data or fuse data from multiple sensors, to detect and/or avoid hazards, and/or to select sites that are safe and traversable by rovers.

## 2.6 Technologies for Low Cost Missions

### Entry, Descent, and Landing (EDL) for small entry probes

Small entry probes present unique challenges since their severe mass, power, and volume constraints generally mean less accurate EDL capabilities than larger systems currently envisioned in the future MEP. Therefore, increasing the EDL capabilities of small probes could lead to future breakthroughs in low cost missions. Several areas are identified below as being of particular interest:

- *Precision control of atmospheric interface point*: Increased precision in controlling the Mars atmosphere interface point leads to increased ability to target surface and near-surface areas. Improved targeting increases accessibility and science return.

- *Small, low power, low cost inertial measurement sensors:* Inertial measurement is required in most mission concepts involving entry and descent. Smaller systems enable more payload and/or smaller probes. Examples of systems in this area are gyros and accelerometers.

- *Low mass, low power, alternative precision guidance techniques:* Currently precision guidance techniques are acceptable for large systems of hundreds to thousands of kilograms. Smaller systems cannot devote the same mass fraction and power fraction to guidance as the larger systems. Therefore, methodologies (algorithms, software, sensors, and actuators) that can provide low mass, low power, low cost precision guidance techniques for future Mars missions are of high importance.

- *Hard landing impact attenuation:* Small, low cost surface missions sometimes cannot afford to have mass devoted to lowering surface impact velocities. Therefore, low mass, low power impact attenuation technologies would enable a new class of future surface landers.

### Lightweight propulsion components

The propulsion system constitutes a large fraction of any low cost mission mass. Reducing the mass and power of the propulsion system allows more payload and more science to be accomplished. Examples of important propulsion system technologies are low mass tanks, filters, regulators, and valves. Optimized thrusters for lower mass systems require lower minimum impulse bit control. Finally, increases in propellant performance ($I_{sp}$) would reduce the required propellant mass.

### Aerial vehicle technology

Aerial vehicles (defined here as airplanes and balloons) require robust, lightweight deployment technologies. For this class of low cost missions, deployment most likely occurs during the descent phase. This NRA solicits innovative aerial vehicles, innovative materials for use in aerial vehicle structures, and lightweight, robust deployment mechanisms. Also critical to this type of low cost mission is guidance and navigation during the atmospheric flight. Finally, because there may be difficulty in returning all of the science data during the atmospheric flight, innovative technologies for post surface impact data return are solicited.

Mars Surface Solar Power Technologies

Landers, rovers, and aerial vehicles will benefit from technologies that will increase power levels and prolong the useful life of space solar power systems. The MEP seeks technologies to provide high efficiency solar cell system, as well as practical (low power, low mass) dust mitigation techniques, for Mars applications.

## 3.0 Programmatic Information

This solicitation is anticipated to be the first of an ongoing sequence of annual Mars Technology Program solicitations. Projects selected under this NRA may be proposed for up to three years in duration, subject to availability of funds. Based on the planned funding profiles and the submission of proposals of appropriate merit, it is anticipated that the approximate distribution of funding and tasks within the topic areas of this NRA will be distributed as follows:

| Topic Area | Approximate Annual Funding $M | Approximate Number of Selections |
|---|---|---|
| • Subsurface Access | $3.0 | 8 |
| • Rover Technology | $3.0 | 10 |
| • Telecommunications | $2.0 | 8 |
| • Planetary Protection | $2.5 | 8 |
| • Entry, Descent and Landing | $1.5 | 6 |
| • Technologies for Low-cost Missions | $3.0M | 10 |

Technology research may be proposed for application to the 2009 MSL mission and later mission opportunities. Technologies applicble to missions anticipated for launch after 2010 may be at a low TRL.

Technologies proposed in anticipation of incorporation into the 2009 MSL mission should already be at a level of maturity consistent with NASA TRL 3, and should be capable of maturation to TRL 6 by the end of the award period. Since it is the desire of this program to demonstrate these technologies in an integrated manner by mid-2005 time frame, such proposals should be limited to a maximum of two years, and structured to describe delivery of software products and their documentation to the Mars Technology Program.

IMPORTANT INFORMATION

As discussed in the *Summary of Solicitation* of this NRA, the Office of Space Science (OSS) now uses a unified set of instructions for the preparation and submission of proposals given in the document entitled *NASA Guidebook for Proposers Responding to NASA Research Announcement - 2003* (or *NASA Guidebook for Proposers* for short) that may be accessed by opening http://research.hq.nasa.gov/ and linking through "Helpful References," or by direct access at http://www.hq.nasa.gov/office/procurement/nraguidebook/ (note that the updated 2003-edition of the *Guidebook* is used for this solicitation).

Section 6 of this NRA's *Summary of Solicitation* contains the Web address relevant to the electronic submission of a Notice of Intent (NOI) to propose and a proposal's *Cover Page/Proposal Summary/Budget Summary*, as well as the mailing address for the submission of the hard copies of a proposal.

In the Proposal Summary, each proposal must clearly indicate which topic area (i.e. Subsurface Access, Rover Technology, Telecommunications and Navigation, Planetary Protection, Advanced Entry, Descent, and Landing, or Technologies for Low Cost Missions) the proposed technologies will address. Failure to provide this information in the Proposal Summary may result in an improper classification of the proposal and a subsequently lower evaluation.

**As a modification to the specifications in the *Summary of Solicitation* of this NRA, 18 copies of the proposal are required, plus the signed original.**

In order to make the best possible use of the funds available, proposers are encouraged to seek cost sharing where appropriate and to propose leveraged use of resources shared with other programs where that is reasonable. Recommendations for funding will be based on the peer evaluation of the technical merits of each proposal using the criteria given in Section C.2 of Appendix C of the *Guidebook for Proposers*, where it is understood that NASA's objectives specifically includes those of NASA's Mars Exploration Program.

The schedule for the electronic submission of Notices of Intent (NOI's) to propose, which are not required but encouraged, and for the hard copies of the proposals is:

- Release Date: May 2, 2003
- NOI Desired Due Date: May 30, 2003
- Proposal Deadline (4:30 p.m. EDT): August 1, 2003

Selections for this MTP solicitation will be made by the Director of the Mars Exploration Program in the Office of Space Science. Questions concerning this program element may be directed to the MTP Program Executive:

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